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(72) Inventor RUD FRIK MADSEN

(54) SEPARATION APPARATUS

(71) We, AKTIESELSKABET DE DANSKE SUKKERFABRIKKER, a company organised under the laws of Denmark, of Langebrogade 5, 1001 Copenhagen K., Denmark, do hereby declare the invention, for which we pray that a patent may be granted to us, to be particularly described in and by the following statement:—

The present invention relates to separation apparatus.

Separation methods based on ultrafiltration or reverse osmosis and in which a solution to be treated is placed into contact with one side of a semipermeable membrane under a pressure greater than the osmotic pressure of said solution to force the solvent or low molecular weight components of said solution through the membrane suffer from the problem of diminishing efficiency due to the build-up on the surface of said membrane of a residue which does not pass the semipermeable membrane. Thus, as the separation proceeds, the efficiency drops off, in some cases to a point where little, if any, permeate passes the semipermeable membrane. Consequently, after some period of operation the device used has to be dismantled so as to replace the membrane.

Various attempts have been made to remove deposits formed on the membrane surface, but the methods developed have not been entirely satisfactory. Agitation of the mixture to be separated, for example with a rotary stirrer, does not provide sufficient inhibition against loss of efficiency. In fact, once a deposit has been formed on the surface it is very difficult to remove it without dismantling the device and cleaning the membrane.

It has also been proposed to subject a solution to be treated to acceleration greater than gravity in a direction away from said one side of the membrane in order to prevent suspended solids contained in said solution from contacting the membrane and to force concentrated solution away from the membrane. However, since this centripetally induced convection within the solution only depends on differences in densities, this prior art method has not efficiently solved the above mentioned problems relating to a gradually decreasing efficiency of the membrane.

It has now been found that the deposition of residue on the surface of the membrane can be eliminated or significantly reduced by rotating the membrane and the solution relative to one another to create a high speed gradient at the surface of said membrane.

The high speed gradient at the surface of the membrane prevents an excessive concentration of solute at the membrane surface by creating a turbulent flow of solution in the proximity of the membrane. Also suspended solids of the solution to be treated are prevented from adhering to and accumulating on said membrane surface.

Due to the rotational movement of the membrane particulate matter which contacts the membrane surface is subjected to an acceleration in a direction parallel to the membrane surface and finally such particulate matter is discharged from the outer edge of the rotating membrane. Consequently, the deposition of impurities and high molecular weight compounds on the membrane surface can be eliminated or significantly reduced without unduly interfering with the flow of solvent and low molecular weight components through the semipermeable membrane.

The invention relates to an apparatus for the separation of a solution into two fractions by means of a semipermeable membrane. These two fractions are referred to as "solute fraction" and "solvent fraction", respectively. The term "solute fraction" means the fraction formed as a result of the removal of solvent and/or low molecular weight components through the semipermeable membrane and the term "solvent fraction" means the fraction consisting of solvent and/or low molecular weight components which have passed through the semipermeable membrane.

The present invention consists in an apparatus for separating a solution into a solute fraction and a solvent fraction as herein defined, comprising a pressure vessel having

inlet means for a solution to be treated and outlet means for a solute fraction of said solution, at least one semipermeable membrane provided within the vessel and secured to a membrane support, means for withdrawing a solvent fraction of the solution from the side of the membrane contacting the membrane support, and a hollow rotatable shaft mounted for rotation within the vessel and carrying the membrane support which consists of one or more circular discs extending substantially perpendicularly to the shaft, the interior of each disc communicating with the interior of the shaft.

The invention will now be described in further details with reference to the drawing which shows a schematic vertical sectional view of an embodiment of the apparatus of the invention.

A cylindrical container 1 having a liquid inlet opening 2 and a concentrate outlet opening 3 surrounds a rotatable hollow shaft 4. The shaft 4 is mounted for rotation in bearings 5. The driving means connected to the shaft 4 are not shown in the drawings. The container 1 is divided into three compartments by dividing walls 6 and these compartments are interconnected through annular passages 7 around the shaft 4. A perforated annular hollow membrane support 8 is mounted on the shaft 4 in each compartment. A semipermeable membrane 9 encloses the membrane support and is attached to the shaft 4. The interior 10 of each membrane support communicates with the interior 11 of the hollow shaft through passages 12. The interior 11 of the hollow shaft 4 also communicates with means (not shown) for collecting the filtrate produced. In operation the liquid to be treated may be pumped under elevated pressure into the container 1 through the inlet opening 2. However, if the permeate is subjected to a vacuum the pressure on the concentrate side need not necessarily exceed atmospheric pressure. In either case, the difference between the pressure of the permeate and the pressure of the liquid to be treated is greater than the osmotic pressure. The liquid supplied to the container 1 passes up through the container 1 towards the outlet opening and flows from one compartment to the following through the passages 7. During the passage up through the container 1 the liquid introduced is brought into contact with the membranes 9 supported by the membrane supports 8, which are rotating at a high speed. Due to this high speed rotation the liquid layer in contact with the membrane surfaces is subjected to high centrifugal force. This high centrifugal force has the effect of forcing impurities and high molecular weight components towards the outer wall of the container at a higher speed than that of the low molecular weight components. Consequently, the impurities and high molecular weight compounds are prevented from forming deposits in the membrane surfaces.

Due to the pressure difference between concentrate and permeate, solvent and other low molecular weight compounds pass through the membranes and into the interior 10 of the membrane support. From there the filtrate thus produced passes through the passages 12 into the interior 11 of the hollow shaft 4 and flows through the collecting means not shown. The liquid flowing out through the outlet opening 3 is thus concentrated relative to the liquid introduced into the inlet opening 2.

WHAT WE CLAIM IS:—

1. An apparatus for separating a solution into a solute fraction and a solvent fraction as herein defined, comprising a pressure vessel having inlet means for a solution to be treated and outlet means for a solute fraction of said solution, at least one semipermeable membrane provided within the vessel and secured to a membrane support, means for withdrawing a solvent fraction of the solution from the side of the membrane contacting the membrane support, and a hollow rotatable shaft mounted for rotation within the vessel and carrying the membrane support which consists of one or more circular discs extending substantially perpendicularly to the shaft, the interior of each disc communicating with the interior of the shaft.

2. An apparatus for separating a solution into a solute fraction and a solvent fraction as herein defined, substantially as hereinbefore described and with reference to the accompanying drawing.

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1417973 COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of the Original on a reduced scale